



# CGIAR System-wide Livestock Programme



Annual Report 1997-98

## About the SLP

Poverty, food insecurity and a deteriorating environment threaten the livelihoods and even the lives of millions of rural people in developing countries. Smallholder farmers in these countries have few resources or opportunities to improve their situation, but one option *is* widely available: by integrating crop and livestock production, farmers can improve their farm productivity while protecting their natural resources.

Operating at the interface between crop-livestock research and research on the management of natural resources, the System-wide Livestock Programme of the Consultative Group on International Agricultural Research (CGIAR) is a unique vehicle for enhancing the contribution of animal agriculture to the CGIAR's objectives of increasing food production, alleviating poverty and protecting the environment.

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## About the CGIAR

The Consultative Group on International Agricultural Research (CGIAR) is a consortium of over 50 public- and private-sector bodies that provide funding for 16 international agricultural research centres and several programmes linking their activities, including the SLP. Founded in 1971, the CGIAR is sponsored by the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP), the United Nations Environment Programme (UNEP) and the World Bank.

The CGIAR's mission is "to contribute, through research, to sustainable agriculture for food security in developing countries". In pursuit of this mission, the CGIAR focuses on five major research thrusts: increasing productivity, protecting the environment, saving biodiversity, improving policies and strengthening national research. It collaborates with a wide range of partners, especially national agricultural research systems, advanced research institutions in the North and the South, universities, the private sector, non-government organizations and farmers' associations.

## Centers supported by the CGIAR

CIAT	Centro Internacional de Agricultura Tropical
CIFOR	Centre for International Forestry Research
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo
CIP	Centro Internacional de la Papa
ICARDA	International Center for Agricultural Research in the Dry Areas
ICLARM	International Center for Living Aquatic Resources Management
ICRAF	International Centre for Research in Agroforestry
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IFPRI	International Food Policy Research Institute
IIMI	International Irrigation Management Institute
IITA	International Institute of Tropical Agriculture
ILRI	International Livestock Research Institute
IPGRI	International Plant Genetic Resources Institute
IRRI	International Rice Research Institute
ISNAR	International Service for National Agricultural Research
WARDA	West Africa Rice Development Association



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# Executive Summary

The System-wide Livestock Programme (SLP) was established in 1995 as one of several system-wide programmes that link activities of the 16 research centres supported by the Consultative Group on International Agricultural Research (CGIAR). Its aim is to add value to the resources already invested in livestock-related research across the CGIAR system and associated ecoregional consortia.

Nine centres participate in the SLP, which has received strong endorsement from the CGIAR's Technical Advisory Committee (TAC). The Livestock Policy Group (LPG), consisting of a representative of each participating centre, decides the SLP's research agenda and advises on its implementation.

The SLP focuses on animal feed resources and natural resource management issues. Value can be added in these areas by:

- Linking the CGIAR system's plant-oriented centres to each other and to ILRI so as to develop a coherent, shared approach to animal feed and natural resource management research problems
- Enhancing the centres' crop improvement programmes so that these produce more genetic materials with residues suitable for use as animal feed
- Developing and promoting the use of standardized methods for the breeding of new crop varieties with good feed quality
- Understanding and exploiting the common features of mixed crop-livestock production systems in different parts of the world
- Encouraging the conduct of research and other activities with benefits that can be transferred across regions
- Promoting a policy and institutional environment conducive to improved livestock production by drawing lessons from specific experiences and transferring them to other situations
- Facilitating the exchange of livestock-related information, materials and methods.

Phase I of the SLP, which ended in 1997, succeeded in strengthening the links of the CGIAR's plant-oriented centres with each other and with ILRI, and allowed coordinated planning and implementation of crop-livestock research by three ecoregional consortia. In 1996 an international workshop on crop residues was held to review past progress and plan



future global research in this area. In 1997 the consortia, led by the Centro Internacional de Agricultura Tropical (CIAT), the International Centre for Agricultural Research in the Dry Areas (ICARDA) and the International Centre for Research in Agroforestry (ICRAF), were awarded funding for projects designed to improve the quantity and quality of feed resources in Latin America, West Asia-North Africa and sub-Saharan Africa.

Of the three projects, those led by ICRAF and CIAT are the most advanced. The ICRAF-led project, based in Kenya's Embu district, focuses on the use of *Calliandra calothyrsus* and other fodder tree species to increase smallholder dairy production in the highlands of Eastern Africa. The SLP is contributing by funding a full-time technology transfer expert to speed up technology diffusion, both in Embu and in other similar areas. The SLP will also contribute to the search for alternatives to *Calliandra*, so as to broaden biodiversity and reduce the risk of pests and diseases, and to the investigation of farmers' manure management practices—important for nutrient cycling.

The objective of the CIAT-led project is to improve the productivity of dual-purpose meat and dairy cattle by introducing woody and herbaceous legumes to the fragile Andean and Central American hillsides and the forest margins of the Amazon Basin. Technology testing, still at an early stage, has demonstrated a good response to the feeding of *Stylosanthes guianensis* to calves in Peru, and the value of a local drought-tolerant shrub, *Cratylia argentea*, as a replacement for expensive protein concentrates in the feed rations of dairy cattle in Costa Rica. The SLP will contribute both to the further testing of technology and to the transfer of results.

In the ICARDA-led project, implementation of which began in 1998, a wide range of fodder shrubs and trees adapted to the dry areas of the Sahel and of West Asia-North Africa is being tested by national partners. Several strategic research themes are also being pursued.

The main challenge at the outset of Phase II of the SLP is to attract increased funding, which has so far fallen well short of TAC recommendations and of the amounts needed to execute the existing programme. To meet donors' priorities, the SLP will promote the development of projects that promise a near-term developmental impact. Phase II will also see increased emphasis on impact assessment and technology diffusion. Six new project proposals are currently being developed for submission to donors by the end of 1998.

The SLP has already demonstrated its potential to increase the value of the resources invested in livestock-related research by the CGIAR and its partners. At the interface between agriculture and the environment, the SLP's research agenda is one that should attract widespread support.

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## Why the SLP?

SLP stands for System-wide Livestock Programme. Established in 1995, the SLP is one of several system-wide programmes that link activities of the 16 research centres supported by the Consultative Group on International Agricultural Research (CGIAR).

Among the 16 centres, the International Livestock Research Institute (ILRI), is the only one explicitly devoted to livestock. But most of the others conduct research relevant to livestock, especially those with a mandate for research on plants whose residues or other parts are used to feed livestock. In addition, many centres conduct research on the management of natural resources, which frequently involves crop-livestock interactions. Hence the opportunity for an inter-centre programme designed to strengthen the coherence and impact of the CGIAR's livestock-related research.



## Livestock in mixed farming systems

Livestock are already important sources of subsistence and cash for small-scale producers in all four of the world's major developing regions—sub-Saharan Africa, West Asia-North Africa, South and East Asia, and Latin America and the Caribbean. The future will bring even greater demand for livestock products, with demand for meat and milk in developing countries more than doubling by 2020 (IFPRI, 1995). This growth in demand will bring significant market opportunities for smallholder livestock producers as well as increasing the pressure on livestock-producing environments. Between 60 and 80% of all livestock are raised in mixed crop-livestock systems (Winrock, 1992), a proportion set to rise still further as cropping expands and intensifies to feed growing numbers of people. Besides providing milk, meat, wool and fibre, livestock in such systems are a means of recycling nutrients, cultivating the soil, controlling weeds, threshing the harvested crop, taking produce to market, storing cash, protecting against adversity and meeting social obligations. As human population rises, the integration of crop and livestock production, already well advanced in some areas, will become increasingly important as a means of intensifying production (de Haan et al, 1998).

Recent studies by the CGIAR centres and their partners have highlighted the growing importance of crop residues



for feeding livestock. In semi-arid sub-Saharan Africa, crop residues provide 45 to 80% of the annual feed intake of cattle, sheep and goats (Winrock, 1992). In India, their sale accounts for 50% of farmers' incomes from crop production (Parthasarathy-Rao, 1985). In the developing countries as a whole, crop residues are thought to supply nearly a quarter of the energy needs of ruminants. These proportions can only continue to rise as the world's cropped area increases.

Livestock interact with the environment in many ways, with important implications for the management of natural resources. For example, mixed farming systems may benefit through the addition of manure to cultivated fields. The requirement to feed their animals can also motivate farmers to introduce leguminous fodder trees and shrubs to such systems, increasing their biodiversity, stabilizing soil and water resources and helping to maintain soil fertility.

To maximize the benefits brought by livestock to mixed farming systems, research must address the interface and interactions among crops, trees and livestock. This is the collaborative research supported by the SLP.



## Adding value

The SLP aims to add value to the resources already invested in livestock-related research across the CGIAR system and associated ecoregional consortia. This can be done by:

- Linking the system's plant-oriented centres to each other and to ILRI so as to develop a coherent, shared approach to animal feed and natural resource management problems
- Enhancing the centres' crop improvement programmes so that these produce more genetic materials with residues suitable for use as animal feed





- Developing and promoting the use of standardized methods for the breeding and evaluation of new crop varieties with good feed quality
- Understanding and exploiting the common features in mixed crop-livestock production systems in different parts of the world
- Encouraging the conduct of research and other activities with benefits that can be transferred across regions
- Promoting a policy and institutional environment conducive to improved livestock production by drawing lessons from specific experiences and transferring them to other situations
- Facilitating the exchange of livestock-related information, materials and methods.

The breeding programmes of the CGIAR's crop-oriented centres are well attuned to human food needs, but less so to farmers' requirements for animal feed. Studies in West Asia-North Africa, for instance, have shown that the adoption of high grain-yielding cereals, particularly barley, is constrained by their low yields of straw—needed to feed the region's flocks of small ruminants. Much is to be gained, therefore, by a small additional effort to encourage these programmes to pay more attention to feed requirements, and especially the feed value of crop residues.

Similarly, several of the centres are now heavily committed to research on natural resource management. Livestock play a critical part in nutrient cycling, an important aspect of such research. They also provide farmers with an economic incentive to adopt resource-conserving technologies such as browse trees and shrubs. These considerations mean that a livestock perspective is often vital to the success of natural resource management research. By encouraging such a perspective within ecoregional consortia, the SLP can add immense value to the overall research effort.



### SLP objectives

*The SLP defines its objectives as to:*

- *Build and strengthen links with and between plant-oriented centres, so as to develop a coherent, integrated approach to the development of livestock feeds, the management of natural resources and the creation of a supportive policy environment.*
- *Influence CGIAR resources invested in centre programmes, ecoregional initiatives and other system-wide activities so as to increase the effectiveness with which livestock feed and natural resource management issues are addressed.*



## Programme Evolution

The concept of the SLP emerged in the early 1990s, as the CGIAR sought to maximize the returns to investments in research by seeking spillovers and synergies from its centre-based programmes. Responsibility for turning the concept into a reality passed to ILRI in 1995, after this centre had been established by merging the International Livestock Centre for Africa (ILCA) and the International Laboratory for Research on Animal Diseases (ILRAD). ILRI's Board of Trustees assumed governance responsibility for the SLP.

### Achievements of Phase I

At ILRI's invitation, nine centres expressed an interest in participating in the SLP. There was a consensus that the programme should focus on animal feed resources and natural resource management issues. ILRI developed a strategic plan for approval by the CGIAR's Technical Advisory Committee (TAC) and constituted the Livestock Programme Group (LPG). The role of the LPG, which consists of a representative from each participating centre, is to agree the SLP's research agenda and advise on its implementation.

The SLP adopted an innovative approach to raising and allocating funds. Centres were encouraged to join with national partners in new and existing ecoregional consortia to compete for grants. Proposals from the consortia were evaluated by an external peer review panel which reported to the LPG. The approach was designed to promote excellence, motivate inter-institutional collaboration and harness substantial matching funds from ecoregional partners.

The CGIAR's Technical Advisory Committee (TAC) provided strong endorsement of the SLP, earmarking funding of US\$ 4 million a year for the programme.



However, at a time when there was a general downturn in unrestricted core resource allocations to the CGIAR, actual funding has turned out considerably lower than expected. The SLP's total funding between 1995 and 1997 was US\$ 1.9 million—well below the level recommended by TAC.

Based on the peer review panel's recommendations, the LPG selected three proposals for funding in 1996. The three proposals came from ecoregional consortia led by the Centro Internacional de Agricultura Tropical (CIAT), the International Center for Agricultural Research in the Dry Areas (ICARDA) and the International Centre for Research in Agroforestry (ICRAF). However, given the uncertainty of funding for these multi-year projects, these centres had to scale down their plans and budgets. Following the receipt of revised proposals, US\$ 0.3 million was awarded to each in 1997.

Despite the funding shortfalls, the SLP has accomplished much in its first 3 years. The two most important achievements are:

- Strengthened links of the plant-oriented centres with each other and with ILRI
- Coordinated planning and implementation of crop-livestock research by three ecoregional consortia.

In addition, seven priority areas for ecoregional crop-livestock research on feed resources and the management of natural resources have been identified. These areas are:

- Improving the nutritive value of crop residues
- Improving the feed resources available for smallholder dairying
- Matching livestock nutritional requirements with local feed resources in different agro-ecological zones
- Nutrient cycling to sustain cropping systems

***“The new global research entity should be allocated US\$ 4 million of core funds to facilitate the establishment of new livestock research programmes of both a global and an ecoregional nature. These funds are intended to build and strengthen links with plant-oriented centres so as to develop integrated programmes on livestock feed and production systems.”—***  
TAC recommendation, December 1995.

- Use of forage legumes in cropping systems
- Use of fodder shrubs for livestock feed
- Practices and policies to improve the management of fragile lands.



### Towards a renewed global effort on crop residues

*One of the SLP's early activities was to fund an international workshop on Crop Residues in Sustainable Mixed Crop-livestock Farming Systems. The workshop was organized by ILRI and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and held in Patancheru, India in April 1996.*

*The workshop brought together 72 scientists from 33 countries in 6 continents to review past work, exchange experiences and strengthen the links that will facilitate future collaboration. Papers were presented on the dynamics of feed resources in the mixed farming systems of each developing region. Other topics explored included trends in the use of crop residues, strategies for enhancing their feed value, and alternatives to crop residues as a means of maintaining soil structure and fertility. A paper on the national perspective was synthesized from the 19 country reports also presented at the workshop. Priorities and recommendations were outlined in five areas: genetic enhancement, crop residues and soil management, feeding systems, modelling, and technology design and transfer. The workshop proceedings were co-published by ILRI, ICRISAT and CAB International.*

*The most important output from the workshop from the SLP's point of view was the development of an inter-centre research proposal on crop residues, soon to be presented to donors. The proposal links the research plans of all 8 of the plant research centres participating in the SLP in order to coordinate and add value to their research.*

## A new beginning

Phase II of the SLP, which started in 1998, presents both challenges and opportunities.

The immediate challenge is to secure increased funding. Donors are increasingly giving priority to projects that offer the promise of a near-term developmental impact. The SLP will seek to identify such projects, without compromising the strategic nature of the CGIAR's longer term research.

The nature of the SLP and its research agenda provide major opportunities to attract renewed support. Donors have indicated that the CGIAR centres must address issues relating to the environment and sustainability at the same time as they seek to raise agricultural production and productivity. Concerned with both agriculture and the natural resource base, the SLP's livestock research agenda is in line with this requirement. The SLP is also well placed to promote the development of a holistic approach to nutrient cycling and resource management at the small farm and watershed levels—another strong donor interest. There is a continuing need to identify and fill critical gaps in the feed resources and natural resource management research of the ecoregional programmes and consortia supported by the





CGIAR. Lastly, the SLP can maximize its impact by seeking projects with operational and/or technological synergies and by developing collaborative activities that add value by working at the interface between ILRI's mandate and those of its partners.

In line with donors' concerns, Phase II will place added emphasis on ex-ante and ex-post impact assessment and on technology diffusion. Before generating new technologies, it is vital to secure maximum adoption of those already developed. Systems analysis to understand adoption constraints and the pathways of system intensification will therefore be undertaken as a priority. Another urgent priority is to obtain funding for a proposal for inter-centre transregional research on crop residues. Several donor representatives have indicated interest in this proposal, which is based on the international workshop on this subject held at ICRISAT in 1996.

In late 1997 the CGIAR's Finance Committee approved a one-time grant of US\$ 2 million to support the development of Phase II. This grant will be used as seed money to fund pilot studies by centre-led consortia. The studies will establish the basis for attracting additional funds to high-priority crop-livestock research areas. With this approach, donors can support well focused research, specified as to location, participants and products. Support can be targeted through the SLP to a specific consortium, which will balance CGIAR contributions with matching funds, including in-kind support from national research institutions.

The LPG will continue to serve as an advisory body and a clearing house for proposals during Phase II. It will provide technical peer review of project proposals, which will be submitted initially in the form of concept notes. It will also approve and evaluate SLP-supported projects, ensuring relevance, transregional planning and links to other research

in the CGIAR system. In addition, the group will seek to promote awareness of the importance of crop-livestock research. The ILRI Board will continue to have responsibility for governance during Phase II.

At its March 1998 meeting, the LPG agreed an action plan for the development of new projects. Since then, six concept notes have been approved and are being developed into full proposals. These are:

- Finding the balance among competing uses for crop residues in mixed farming systems of sub-Saharan Africa, West Asia-North Africa, South and East Asia and Latin America and the Caribbean. This has four modules, whose lead centres are the International Institute of Tropical Agriculture (IITA), ICRISAT and ILRI (the latter centre is responsible for two modules)
- Crop-livestock farmers in the dry savannas of Western Africa working with scientists to improve the productivity and sustainability of their farming systems. Lead centre: ICRISAT
- Raising livestock productivity in the mixed crop-livestock systems of South Asia. Lead centre: ICRISAT

#### Criteria for project approval

*During Phase II the LPG will use the following criteria to assess concept notes and project proposals:*

- *Scientific quality: problem definition, use of appropriate methods, feasibility of the research*
- *Conformity to CGIAR and SLP priorities*
- *Potential for impact: ecoregional, transregional*
- *Budget requirements and financing strategy*
- *Partnerships: CGIAR centres, regional and national institutions (consortia).*

- Improving crop-livestock productivity through efficient nutrient management in the mixed farming systems of semi-arid Western Africa. Lead centre: ILRI
- The maize crop as food, fodder and fertilizer in intensifying crop-livestock systems in Eastern and Southern Africa. Lead centre: Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT)
- Use of geographical information systems to target the multiple uses of legume technologies for sustainable agriculture. Lead centre: CIAT.

These proposals are being informally discussed with donors and will be submitted by the end of 1998.



## Progress Report

Of the three projects currently supported by the SLP, those led by ICRAF and CIAT are the most advanced. The project led by ICARDA is still at an early stage of implementation. All three, however, place considerable emphasis on the spillover of benefits to other areas and regions—an objective shared by the SLP and to which the SLP will contribute.

### More milk for Eastern Africa

Kenya's Embu District is a high-potential area of the Eastern African highlands. It has fertile soils, adequate rainfall and produces a wide range of crops, including tea and coffee in addition to maize, beans, vegetables and many fruit and timber tree species. Livestock, and especially dairy cows, play an important part in meeting farmers' cash and subsistence needs through the consumption and sale of milk. However, in Embu as elsewhere in the highlands, the mixed crop-livestock production system is under pressure as human population continues to rise. Interventions that increase cash incomes while protecting the environment are vital to raise people out of poverty and conserve a fragile resource base prone to erosion and declining soil fertility.

ICRAF has been contributing to collaborative research in Embu District since the late 1980s. The major focus of research is the feed shortages faced by the district's many small-scale dairy farmers. Several other partners play a vital part in generating and disseminating the technology needed to overcome this problem. There is strong collaboration between Kenya's national agricultural and forestry research institutes—a sign of the progress made in recent years in overcoming sectoral barriers in research. Leading the research effort is the Kenya Agricultural Research Institute (KARI), which has a station in the area, while the Kenya Forestry





Research Institute (KEFRI) provides technical expertise on tree and shrub introduction and management. The research effort builds on the results achieved by a successful KARI-ILRI collaborative dairy project in coastal Kenya, which in 1997 was awarded the CGIAR Chairman's Award for Outstanding Scientific Partnership.

In Embu, as in the coastal project, strong links have evolved between research and extension. Embu is home to both the district and the provincial offices of the national extension service, allowing more intensive contact with local farmers than is possible in some other areas. KARI has had a presence in the region since the 1950s, allowing it to win the confidence of farmers with a steady stream of new technologies, particularly new maize varieties. Farmers are open to the products of research and actively seek the advice of the research and extension services.

Two projects supported by donors were instrumental in introducing and disseminating new technology to solve the feed shortage problem. The National Dairy Development Project (NDDP) first tested new fodder species with farmers in the early 1990s. Its successor, the National Agroforestry Research Project (NARP), has extended the on-farm research and launched more widespread technology transfer efforts. Other international research efforts in the area include those of another system-wide CGIAR programme, the African Highlands Initiative (AHI), through which ICRAF and ILRI collaborate with national research and development agencies to increase the productivity of smallholder agriculture and improve the management of natural resources through the integration of crop and livestock production.



The on-farm research conducted by NARP has established that, of the three fodder tree species originally tested, *Calliandra calothyrsus* is the most productive and the most popular with farmers. It grows well in niches widely available in farmers' fields—in napier grass and below the canopy

of *Grevillea robusta* trees—without displacing other species. When grown along the contour, it forms a thick hedge, helping to conserve soil moisture and prevent erosion. Most important, the tree has proved highly palatable to dairy cows and hence a useful, low-cost substitute for the expensive dairy meal that farmers have to buy at present. Around 6 kg of fresh matter (equivalent to 2 kg of dairy meal) is needed to meet the daily protein supplement required to keep a dairy cow productive. To produce this amount of fodder daily, farmers need to grow around 500 trees on their land. Most have room for twice this number.



A recent survey showed that more than 1500 farmers have spontaneously adopted the use of *Calliandra* since 1991. About half of them are using the tree to replace dairy meal, while the other half are using it as an addition to dairy meal. Economic analysis of these two strategies has shown them to be about equal in profitability, resulting in an average increase in farmers' incomes of US\$ 165 per cow per year. Widespread adoption of the technology could save the small-holder dairying sector an estimated US\$ 102 million annually.

Demand for seedlings is vastly outrunning supply. ICRAF is working with KARI and the extension services to help fill the gap by establishing nurseries and training local communities in their management. In 1997, 20 such nurseries were established and some 49 000 young trees were distributed to farmers. Extension pamphlets have also been produced.

The SLP's contribution to the project will help to speed up dissemination still further. Funded by the programme, a full-time technology transfer expert will join the team in Embu in 1998, with a brief to help spread the technology to other relevant areas of Eastern and Southern Africa in addition to intensifying efforts within Embu District. The challenge will be to spread the message, and the technology itself, to areas less well endowed with institutional support than Embu. The task of technology transfer fits well with the SLP's mandate to achieve spillovers from the research of individual centres. It also chimes with donors' concern to see resources channelled to projects with a near-term developmental impact.

A second area to which SLP funding will contribute is research to increase the biodiversity of fodder shrubs available to farmers in Embu District and other highland areas. In 1992 one of the species under testing, *Leucaena leucocephala*, was all but wiped out by an epidemic of psyllid, a leaf-eating insect from Southeast Asia. The experience taught farmers and researchers how vulnerable the smallholder dairying sector is to outbreaks of pests and diseases if it relies on one or two fodder species alone. In a project with the UK's Oxford Forestry Institute, researchers are seeking to broaden farmers' options. Among the alternatives being investigated are different provenances and species of *Calliandra*, and a new, highly productive species, *Acacia angustissima*.

Little is known about the soil fertility effects of *Calliandra*, but the plant is not thought to make a significant

contribution to soil nitrogen. Other organic sources of nutrients are scarce, highlighting the need to make the best possible use of those that are available. The most plentiful resource for smallholder dairy farmers is farmyard manure. Most crossbred cows are stall-fed, facilitating the collection and spreading of manure on crop fields. However, farmers' manure management practices have not so far been investigated by researchers and may well leave room for improvement. This is a third area of research to which SLP funding will contribute.

## Tackling feed shortages in tropical Latin America

Dual-purpose (milk and meat) production systems account for nearly 80% of the cattle and supply about 40% of the milk produced in tropical Latin America. Most systems of this kind are found on small to medium-sized farms on which pasture is the main feed resource. The main constraints to increased productivity are the quantity and quality of feed available, especially during the dry season, together with the animals' genetic potential. As a result the milk supplied from such systems falls well short of demand.

Researchers at CIAT have introduced and tested improved grasses and legumes that have the potential to overcome the feed constraint. Grasses adapted to low-fertility acid soils have been quite widely adopted, but legumes remain underused despite their ability to improve and protect soils in addition to increasing the protein content of the diet. Current research by CIAT, ILRI and their national and regional partners therefore emphasizes the introduction of woody and herbaceous legumes. Efforts are concentrated in the fragile Andean and Central American hillsides and the forest margins of the Amazon Basin, where the needs are greatest.



In both these ecologies, the feed shortage, combined with the subsistence and cash needs of an impoverished human population, means that livestock production is increasingly accompanied by problems of resource degradation. In the seasonally dry hillsides, cattle are often turned loose into areas of remaining natural forest on steep slopes, where they deplete vegetation, cause soil erosion and frustrate attempts at re-afforestation. In the forest margins, degraded natural pasture is typically the end product of the process that begins with slash-and-burn cultivation, as the diminishing returns to annual crops caused by declining soil fertility force farmers into livestock production. In both cases, introducing improved grass-legume pastures would not only help overcome the feed shortage but would also take the pressure off primary and secondary forest lands. Farmers' incomes and local job opportunities would benefit too.

In 1996, a CIAT-led consortium of national, regional and international partners, including ILRI, launched a new project designed to increase milk production from small-holder farms in these ecologies. The project, known as Tropileche (tropical milk), is based at two benchmark sites in the Pucallpa region of central eastern Peru and the Central





Pacific region of Esparza, Costa Rica, representing the forest margin and hillside ecologies respectively. The two sites were chosen for their representativeness and for the presence of a strong national research capacity—factors that should lead rapidly to the achievement of reliable results and their extrapolation to similar areas. The project does not cover the high Andean zone, where the climate is temperate rather than tropical.

The research effort at national level focuses on forage agronomy and livestock nutrition and production. In Peru, on-station research is led by the Instituto Veterinario de Investigaciones Tropicales y de Altura (IVITA), which also serves as country coordinator, while on-farm research is the shared responsibility of the Instituto Nacional de Investigación Agraria (INIA), the Instituto de Investigación de la Amazonía Peruana (IIAP) and the Universidad de Ucayali. All these institutions, together with non-government organizations (NGOs), are members of the Consorcio para el Desarrollo Sostenido de Ucayali (CODESU), a regional development consortium.

CIAT's main partners in Costa Rica are the Ministerio de Agricultura y Ganadería, acting as country coordinator and responsible for on-farm research, and the Escuela Centroamericana de Ganadería (ECAG), where controlled experiments are carried out. Other institutions supporting the research process are the Universidad de Costa Rica (UCR) and the Centro Agronómico Tropical de Investigación y Enseñanza (CATIE).

Tropoleche also has access to the expertise and resources of two international centres—CIAT for forage development and land use characterization, and ILRI for livestock production. Cornell University supports the research process through its work on the modelling of ruminant feeding strategies.

The local research effort at each site has three components. First, strategic, largely station-based, research is being used





to determine synergism among local and improved feed resources for different classes of livestock, including small ruminants and cows of various genotypes. Special attention is being paid to the identification of the most effective forms of dry-season supplementation. Second, improved feeding systems are being evaluated on farm using participatory methods. The emphasis here is on improved grass-legume pastures for the milking herd and on legume fodder banks to promote the early weaning of calves. Both technologies should increase the amount of milk available for family consumption and sale. Third—and most important—socio-economic research is being conducted to aid technology transfer by diagnosing farmers' problems, characterizing the benchmark sites and other similar areas and studying the acceptability of improved forage and management technologies at farm level. This research will also examine the environmental impact of the new legume-based forage systems.

The two benchmark sites have already been characterized through diagnostic surveys. The surveys at the Costa Rica

hillside site have confirmed that dry-season feeding is the main constraint faced by small-scale livestock producers, who expressed considerable interest in improved legume-based pastures and in shrub legumes with drought tolerance. During the dry season farmers are forced to overgraze their pastures and buy expensive concentrates to cope with the feed shortage. In Peru, surveys revealed the low stocking rates used on unimproved pastures—only 3% of producers had more than 2 head of cattle per hectare. Farmers lack the necessary capital to increase their livestock numbers, which were drastically reduced during the long years of guerrilla war in the countryside. Cattle owners nevertheless tend to have larger farms than non-cattle owners, with lower proportions of forest and cropped areas.

Technology testing is still in its early stages. In Peru, feeding the legume *Stylosanthes guianensis* to calves increased their growth rates, releasing an extra 1 kg of milk per cow per day for sale at local markets. In Costa Rica, the shrub legume *Cratylia argentea*, which has high drought tolerance, is being fed to milking cows during the dry season in combination with sugar cane—a technology that replaces expensive protein concentrates without reducing milk yield.

From the start of the project, considerable emphasis is being placed on technology transfer, with links to other consortia and research groups explicit in the research agenda. The SLP welcomes this emphasis and hopes to build on it. Research at the Pucallpa benchmark site should prove





applicable to other forest margin areas in Brazil, Colombia, Ecuador and Peru, while that at the Esparza site will be relevant to other seasonally dry hillside areas in both Central and South America. Pucallpa is also a benchmark site of the international Alternatives to Slash-and-Burn (ASB) programme, which will take up relevant results and apply them to forest areas in Southeast Asia and sub-Saharan Africa. Extrapolation from the Costa Rica site will be assisted through land use and diagnostic studies conducted in collaboration with the Central American Hillsides consortium, also supported by CIAT. Already, national institutions in Nicaragua and Honduras have joined the research effort.

### Fodder shrubs and trees for West Asia-North Africa and the Sahel



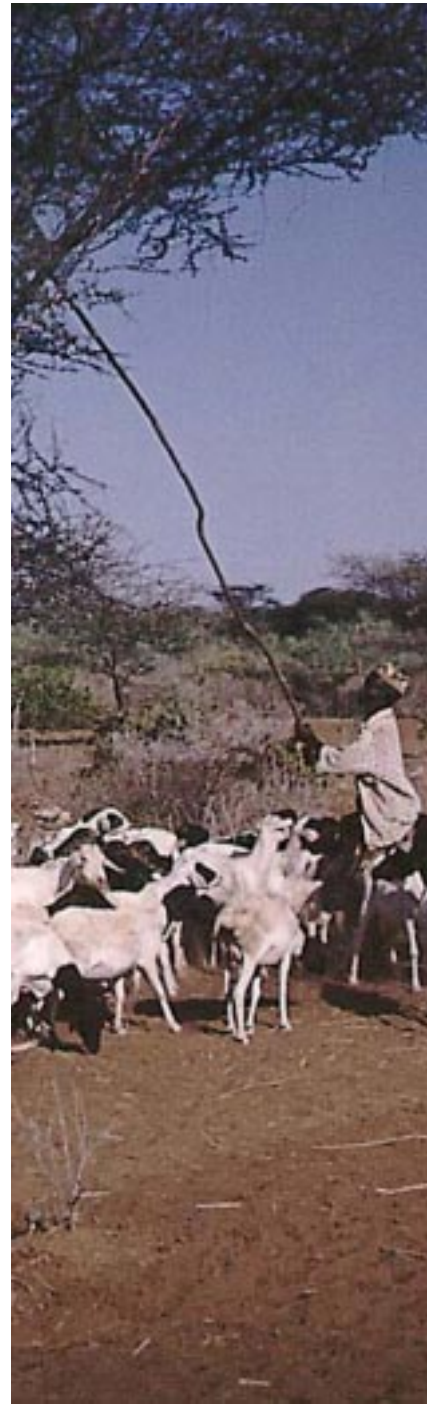
The countries of West Asia-North Africa and the Sahel share an arid to semi-arid climate characterized by a highly seasonal pattern of rainfall and large variations in the amount of rain received both between and within seasons. This results in periodic feed shortages for the large populations of ruminants raised in both regions. Shortages are especially severe during the dry season, which can last up to 5 months during which no rain at all is received. Animals generally lose body condition during this period, leading not only to reduced productivity but also to lowered fertility and increased susceptibility to diseases.

Researchers have long attempted to increase the supply and enhance the utilization of animal feeds, using both native and exotic fodder species. Fodder shrub and tree foliage with a high protein content can be used to supplement the low-value crop residues and pastures that make up the bulk of the diet. Several promising species adapted to arid conditions and able to supply feed well into the dry season have been identified. In West Asia-North Africa these include salt-

tolerant *Atriplex* and *Salsola* spp. in addition to *Acacia* spp. These species are suited to open rangeland, although careful management is needed to ensure their survival during the early years, when a combination of grazing livestock and harsh climatic conditions can easily lead to their demise. In the Sahel, the genera *Combretum*, *Prosopis*, *Gliricidia*, *Pterocarpus* and *Ziziphus* have proved suitable for growing in farmers' fields, but more information on methods of establishment, integration into crop-livestock systems and utilization by small ruminants is needed before widespread technology dissemination can be recommended. Genera such as *Acacia*, *Balanites*, *Bauhinia* and *Kigelia* grow naturally in open rangeland or in crop-parkland systems, where they have potential as fodder banks, windbreaks and hedges.

In both regions, national research institutions are giving high priority to improving small ruminant productivity. For this reason a transregional consortium was formed in 1995 to promote the production and use of multi-purpose fodder shrubs and trees through a project proposed for funding under the SLP. International members of the consortium include ICARDA as lead centre, with ICRAF, ILRI and ICRISAT supporting research in the Sahel. The national institutions involved are those of Morocco and Tunisia in North Africa, of Jordan, Pakistan and Syria in West Asia, and of Burkina Faso, Mali, Niger and Senegal in the Sahel. The project was developed through a consultative process with representatives of national institutions, who attended a workshop in Tunisia in June 1995. This was followed by a further meeting in Syria in February 1996, at which all the members of the consortium finalized the project's work plan. When funding was reduced this work plan was curtailed to a few key activities, which began in early 1998.

One key activity is germplasm screening, with a view to broadening the number of species available and disseminating those already identified more widely. Screening will take place at two locations in West Asia-North Africa—in



the Baluchistan region of Pakistan, representing the arid highlands, and on the Syrian steppe, representing the marginal lowlands—and at a range of locations in the four Sahelian countries.

Several experiments on tree and shrub productivity and feed value are already under way. In Jordan, the productivity of two species of *Atriplex* is being investigated at different planting densities, the aim being to find out whether rainfall is used more efficiently in closely spaced plants than in widely spaced ones and which species and densities give the best yields. In Tunisia, combinations of foliage from different species of *Atriplex*, *Acacia* and native rangeland are being evaluated in feeding trials with sheep. Research in Morocco focuses on alley farming systems in which *Atriplex*, *Salsola* and *Periploca* spp. are grown with barley. The fodder shrubs will provide additional protein to sheep grazing on barley



stubble during the dry season, thereby enhancing body condition and fertility. In Mali, scientists are testing a range of techniques for managing *Bauhinia rufescens* and *Leucaena leucocephala*, also with a view to using these species to fatten sheep. *B. rufescens* is also under research in Niger, together with *Kigelia africana* and several other species of potential importance in ruminant diets. And in Senegal, the contribution of trees to soil nutrients and organic matter in parkland systems is being investigated, together with the influence of *Acacia albida* on crop production.



A number of strategic research themes will also be pursued. Earlier studies by ICARDA found considerable variation in the palatability of *Atriplex* spp. to sheep. The reasons for this will be investigated. ICARDA will also conduct research on the cold tolerance of shrubs and trees for West Asia-North Africa. ILRI, ICRISAT and ICRAF will investigate the vegetative propagation, yield potential and nutritive value of a range of promising but hitherto underused species for the Sahel. The studies on nutritional value will increase understanding of the ruminal breakdown of nitrogenous compounds in foliage and how this is affected by the presence of anti-nutritional factors such as tannins.



## Who Participates and Why?

The SLP is one of the principal elements in ILRI's strategic plan for the globalization of livestock research in the CGIAR through collaboration with ecoregional consortia consisting of CGIAR centres and their national and regional partners. By introducing a livestock perspective into the research plans of these consortia, the SLP adds value to their research and, in the case of new consortia, reduces the transaction costs of establishment. The SLP's emphasis on feed resources from cropping systems and on natural resource management fits well with priority research areas in the medium-term plans of ILRI and the eight other participating centres. The relevant programmes of these centres are described below.

### Centro Internacional de Agricultura Tropical

Demand for livestock products in Latin America and the Caribbean is rising fast. All three of the major ecoregions under research by CIAT—the savannas, hillsides and forest margins—are important, actually or potentially, for livestock production. In addition, the Centre holds a global mandate for the development of improved tropical forages.

Among the livestock-oriented research themes of special interest to CIAT, the development of improved grasses and legumes is the one in which most progress has been made. Grasses such as *Brachiaria decumbens*, *B. dictyoneura* and *B. brizanthia* and legumes such as *Arachis pintoi* and *Stylosanthes guianensis* have been widely introduced on livestock farms in the Latin American lowlands. Much of CIAT's research on the management of natural resources is relevant to livestock production, especially research on the protection of hillside areas prone to erosion and on the sustainability of production in areas cleared from forest in the Amazonian



Basin. Studies on land use, supported by a geographical information system, also cover livestock-related topics.

CIAT leads a consortium to promote smallholder dairying in the region's humid and subhumid tropics. Known as Tropileche, the consortium collaborates with the SLP in research to alleviate the feed constraints faced by smallholder producers of dual-purpose (milk and beef) cattle in marginal areas. The research focuses on the identification of tropical grasses and legumes (herbaceous and woody) for different agro-ecosystems and the use of forage plants to maintain and diversify the natural resource base as well as feed animals. Other areas in which there is scope for an SLP input include the utilization of crop residues and agro-industrial byproducts to feed animals.

## Centro Internacional de la Papa

CIP's research has two important links to livestock production. First, while sweet potatoes are primarily a human food, their vines are widely used as an animal feed. Second, livestock are important for subsistence and incomes and play a critical role in the management of natural resources throughout Andean Latin America, a sizeable ecoregion in which CIP conducts much of its research. Cattle are found at lower altitudes in the Andes, while alpaca production



predominates on the higher slopes. Livestock fulfil multiple functions in the region's mixed crop-livestock systems: food supply, energy source, fertilizer source and link to local markets.

The second of these themes is the subject of collaborative research between ILRI, CIP and other partners in the Consorcio para el Desarrollo Sostenido de la Región Andina (CONDESAN). The partners are working to sustain and increase livestock production on fragile lands prone to soil erosion, to increase forage production and utilization, to improve nutrient cycling and the use of crop residues, and to solve the problems of delivering livestock products to market in remote mountain areas. CIP also conducts research on policy issues affecting milk production for the CGIAR's Global Mountain Initiative.



The SLP will prove a useful vehicle for disseminating CIP's livestock-related research results and methods. With the SLP's backing it may eventually be possible to start work on the first of the two themes, so far under-researched at CIP.

### Centro Internacional de Mejoramiento de Maiz y Trigo

In many parts of the world where wheat and maize are important food crops, population pressure is forcing farmers to intensify their cropping practices. Livestock are often a

key component in these more intensive farming systems, providing food and a cash income in addition to draught and manure to supplement and subsidize the production of cereals. In turn, the straw and stover obtained from wheat and maize are important sources of livestock feed.

One of the challenges facing CIMMYT is to make the best possible use of crop residues as feeds while maintaining organic inputs to the soil that preserve or enhance its physical and chemical characteristics. The SLP provides the Centre's researchers with opportunities to form partnerships with livestock scientists to address these complex interactions more effectively. Such collaboration is already a feature of CIMMYT's research on mixed crop-livestock systems in the highlands of Eastern Africa, where farmers grow both maize and wheat, and in the mid-altitude ecologies of both Eastern and Southern Africa, where maize is the key food staple.

Another important livestock research theme for CIMMYT is improving the nutrient quality of farmyard manure, both alone and in combination with inorganic fertilizers. There is also a need to examine techniques such as the thinning of seedlings and the stripping of leaves, which may improve feed supplies from a growing maize crop while maintaining acceptable levels of grain yield.





## International Center for Agricultural Research in the Dry Areas

Small ruminants are the most numerous and most important livestock species in the dry areas of West/Central Asia and North Africa served by ICARDA. They make a significant



contribution to the farm economy in mixed crop-livestock systems, and in areas too dry for cropping, where steppes and rangeland are found, they are usually the sole source of income and a vital source of subsistence. Their importance as a means of building and storing capital is heightened by the fact that poverty levels are often high in dry areas.

Livestock research at ICARDA emphasizes the efficient use of existing and new feed resources by small ruminants in both the rangelands and the cropped areas. The most plentiful existing feed resource in arable areas at present is crop residues, but these are low in quality. New technology is needed to enhance both their quality and their utilization within the animal. The quality and quantity of the overall diet could also be improved through increased production of forage legumes. Together with more effective use of animal manure, forage legumes would have the added benefit of increasing the organic matter content of soils, helping to sustain crop production. A number of fodder shrubs could also prove useful in boosting feed supplies, either on open

rangeland or in farmers' fields. Improved feed resources and utilization in the arable areas would relieve the pressure on native pastures, which are becoming severely degraded.



ICARDA already has its own research on fodder shrubs. The SLP supports this research through an ICARDA-led consortium of national and international programmes in West Asia-North Africa and the Sahel, in which ICRISAT, ILRI and ICRAF also participate. Another livestock-oriented research theme at ICARDA that could benefit by SLP involvement is the screening of barley germplasm for straw quality. This research, so far focused on the development of simple laboratory screening methods, will shortly shift from on-station to on-farm experiments in which farmers will participate in germplasm screening. Generally, the better links between CGIAR centres and national programmes fostered by the SLP should encourage the latter to conduct more research on the management of natural resources, including the small ruminant component.

## International Centre for Research in Agroforestry

Throughout Eastern and Southern Africa the number of small-scale dairy farmers is increasing rapidly, as urban markets for dairy products grow. In Kenya alone, there are



now an estimated 400 000 of them. Typically, such farmers own two or three grade cattle and manage them in a cut-and-carry feeding system. Most farmers rely on purchased dairy meal supplements to sustain their milk yields. Besides being expensive, these supplements are of variable quality. Farmers need alternative sources of high-quality feed, especially during the dry season when fodder supplies decline in both quantity and quality.

In recent years ICRAF has worked with over 2000 dairy farmers in the subhumid tropics of Kenya, Uganda, Tanzania, Zimbabwe, Zambia and Malawi to evaluate high-quality fodder shrubs and trees. Exotic species such as *Calliandra calothyrsus*, *Acacia angustissima* and psyllid-tolerant *Leucaena* spp. have shown great promise and many farmers have already adopted their use.

ICRAF's interest in the SLP lies in disseminating these proven technologies still further. There is also a great need to diversify the fodder options available to farmers, broadening the genetic base of feed supplies in order to stabilize the small-scale dairying sector in case of attack of existing fodder species by pests and diseases. Lastly, the manure management strategies of farmers need investigating to find out whether there are opportunities to increase the efficiency of nutrient cycling.

### International Crops Research Institute for the Semi-Arid Tropics

Three of the crops under research by ICRISAT—sorghum, millet and groundnut—produce stover and other residues of critical importance in meeting the feed requirements of livestock used largely for draught and for milk production in the mixed crop-livestock systems of the semi-arid tropics. Past research at ICRISAT has documented the contribution of sorghum straw to the total value of the sorghum crop

and shown how this is increasing over time with rising incomes and urbanization. Other research has investigated the part played by sorghum and millet straw yields and quality in farmers' decisions whether or not to adopt modern cultivars. The results led to important changes in the criteria used to select and breed these two important food staples.



Improving the feed quality of stovers and straws is the objective of a collaborative project among ICRISAT, ILRI and national partners. An animal nutritionist from ILRI works closely with plant breeders at ICRISAT to screen the non-grain parts of sorghum and pearl millet plants for in vitro and in vivo digestibility and chemical composition. This will be complemented by in vitro evaluation for those genotypes that show the largest differences in these traits. Additional chemical characteristics and effects on animal physiology will also be identified.

Scientists from ICRISAT, ILRI and the International Food Policy Research Institute (IFPRI) are currently designing a project that will address several strategic issues related to the evolution of crop-livestock systems. Following an exercise to update and expand its data base, ICRISAT scientists were able to create a typology of rainfed agriculture in India that



includes livestock. The new proposal is to develop a typology of mixed crop-livestock production systems, with subsequent characterization and systems analysis. The aim is to help prioritize constraints and identify opportunities to improve the performance of specific systems and their components. The typology should prove useful in Africa as well as elsewhere in Asia.

## International Institute of Tropical Agriculture

Rising human population and urbanization are exerting pressure on mixed crop-livestock production systems throughout sub-Saharan Africa and particularly in Western Africa. As systems intensify, fallow periods are being reduced or eliminated and the rangelands traditionally used to raise livestock are being converted to crop land, forcing increased dependence on crop residues as the major feed resource. Intensification is also bringing increased opportunities to use livestock to maintain soil fertility through the provision of manure. And, as young males migrate to the cities, the use of animal draught may help an ageing and largely female rural population to cultivate the land more efficiently.



Much of IITA's livestock-oriented research is conducted in collaboration with ILRI, which has research facilities on IITA's Ibadan campus. Aspects currently studied by the two centres include the development of new cultivars that maintain their human food value while providing nutritive crop residues for livestock, the introduction of herbaceous legumes to improve soils and provide fodder, the benefits of integrated crop-livestock production and the development of tools to predict changes in land use and their effects on feed resources. One study has shown that farmers using fallows improved with herbaceous legumes can increase their cereal yields considerably by allowing livestock to graze post-harvest residues and deposit manure—



results that powerfully demonstrate the potential of better integrated production systems.

The SLP provides opportunities to build on these studies and maximize their impact. In new cultivar development, several of the approaches used by IITA have relevance elsewhere in the CGIAR system, including the use of molecular markers for fodder quality assessment. In crop-livestock integration, more research is needed on the impact on soil structure and fertility of feeding crop residues to animals, since residues are often used as mulch at present. There is also a need to expand the on-farm testing of proven technologies for systems in which crop and livestock production are relatively well integrated—an activity already initiated through collaborative research with ILRI and ICRISAT. Another area of interest is the adaptation of animal traction to a wider range of situations than those in which it is used at present, particularly in the more humid areas where livestock populations are starting to increase more rapidly. Lastly, IITA plans a further project with ILRI to develop and test methods for predicting land use changes and their effects on feed resources throughout sub-Saharan Africa.



## International Livestock Research Institute

Feed resources and natural resource management research are key components of ILRI's global livestock agenda. For the millions of resource-poor households that depend on livestock, it is vital to increase the quantity and improve the quality of feed available. This must be done without endangering the natural resource base, under conditions of rapidly growing human populations—a challenge that fully justifies an international research effort. ILRI regards the SLP as an important opportunity to build the partnerships essential for success.

All three of ILRI's programmes—Biosciences, Sustainable Production Systems and Strengthening Partnerships with



National Research Systems—contribute to the SLP, as do 11 of the 20 projects making up the centre's Medium-term Plan (1999-2001). Five of these projects—concerned with ecoregional systems research in various agro-ecological zones of sub-Saharan Africa, South and East Asia, Latin America and the Caribbean and West Asia-North Africa—are executed in close collaboration with other CGIAR centres and the ecoregional programmes and consortia they lead. Like the SLP, these projects focus primarily on animal feed and natural resource management research.



The six other projects have a thematic focus. Two of them—on improving feed utilization and understanding rumen microbiology—are concerned with strategic aspects of research on animal feed resources. The other four—on forage characterization and conservation, systems analysis and impact assessment, livestock policy analysis and market-oriented smallholder dairy production—have results that will feed into the SLP. They also play an important part in transregional analyses and extrapolation.

## International Rice Research Institute

Of the world's developing regions, Asia is the one in which the demand for livestock products is expected to rise most rapidly. Feeding livestock is a major challenge for most small-scale Asian farmers. This is especially true in the region's uplands, where the largest concentrations of resource-poor farmers are found. But livestock are also raised in irrigated rice systems, where they are extensively used for draught.

Livestock-oriented research at IRRI focuses mainly on the feed value of rice straw. Research is also conducted on the integration of forage and dual-purpose legume crops into irrigated and upland production systems. Research to improve the productivity and efficiency of dual-purpose (milk and draught) cattle and buffalo is implemented by



national partners using a networking approach to which IRRI has provided some support in the past.

IRRI welcomes the SLP's involvement in the region and the opportunity to collaborate where appropriate. Initially, collaboration will be established with livestock scientists in Asia and with CIAT's Asian Forages Development Project.

## Financial Statement

With the establishment of ILRI in 1995, the mandate for international livestock research was expanded to a global mandate from the previous focus by ILCA and ILRAD on sub-Saharan Africa. As part of the Board-approved Strategic Plan for ILRI, the SLP was initiated as a major component of the globalization strategy.

In 1995 and 1996, Denmark and the Netherlands provided US\$ 0.65 million in support of the globalization of ILRI's programmes. These funds supported the establishment of the SLP, along with consultations with representatives from national research systems, advanced research institutes and other CGIAR centres in Asia, Latin America and Africa. An additional US\$ 0.37 million was allocated from unrestricted funds to support development of the global agenda for livestock research, including the SLP. For 1997, Denmark, Germany and Switzerland provided US\$ 1.03 million to support the SLP. These funds were primarily used for the grants to the CIAT-, ICARDA- and ICRAF-led ecoregional consortia, totalling US\$ 0.9 million.

As of July 1998, US\$ 2.45 million was available to the SLP. Of this, US\$ 2.00 million is a special grant from the World Bank to support the development of Phase II in 1998-2000. The balance was provided by Germany (pledged) and Switzerland.

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## References

- IFPRI (1995). Global food projections to 2002: Implications for investment. Food, Agriculture and Environment Discussion Paper 5. International Food Policy Research Institute, Washington DC, USA.
- Winrock (1992). Assessment of animal agriculture in sub-Saharan Africa. Winrock International, Morrilton, Arkansas, USA.
- De Haan, C., Steinfeld, H. and Blackburn, H. (1998). Livestock and the environment: Finding a balance. A study coordinated by the Food and Agriculture Organization of the United Nations, the United States Agency for International Development and the World Bank. Report of the study sponsored by the Commission of the European Communities, the World Bank and the governments of Denmark, France, Germany, the Netherlands, the United Kingdom and the United States.
- Parthasarathy-Rao, P. (1985). Marketing of fodder in rural and urban areas of India. In: Agricultural Markets in the Semi-arid Tropics. International Crops Research Institute for the Semi-Arid Tropics, Patancheru, India.



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